ACCURACY OF CENTER OF PRESSURE DETERMINATION VIA MOTION CAPTURE

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Introduction

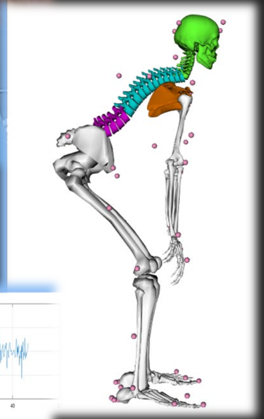
- **Background:** This study was conducted to support stability assessment for:
  - Tasks in lunar gravity [1]
  - Exercises on a Vibration Isolation and Stabilization (VIS) system in microgravity

  Stability assessment based on the dynamic feasibility criterion of whether the calculated position of the center of pressure (COP) falls within the base of support (BOS) which outlines the subject's feet
- **Why use motion capture data to determine COP?**
  - Other gravitational environments
  - Account for the forces and moments between a human and the VIS platform
  - Offloading System
  - Applications for which force plates are not available
- **Goal:** Assess the accuracy of the COP trajectory calculated using motion capture-based data

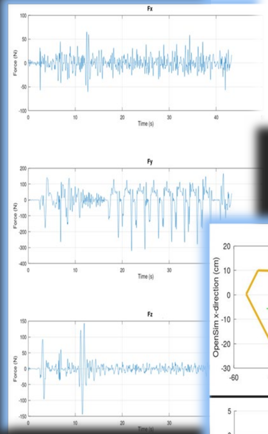
Methods

1. Collect motion capture and force platform data

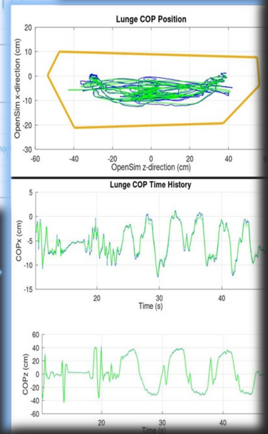
2. Process motion capture data with OpenSim tool and custom plugin [2, 3]



3. Calculate force and moment exerted by the platform on a subject [4]



4. Calculate center of pressure [1] and compare with force platform COP

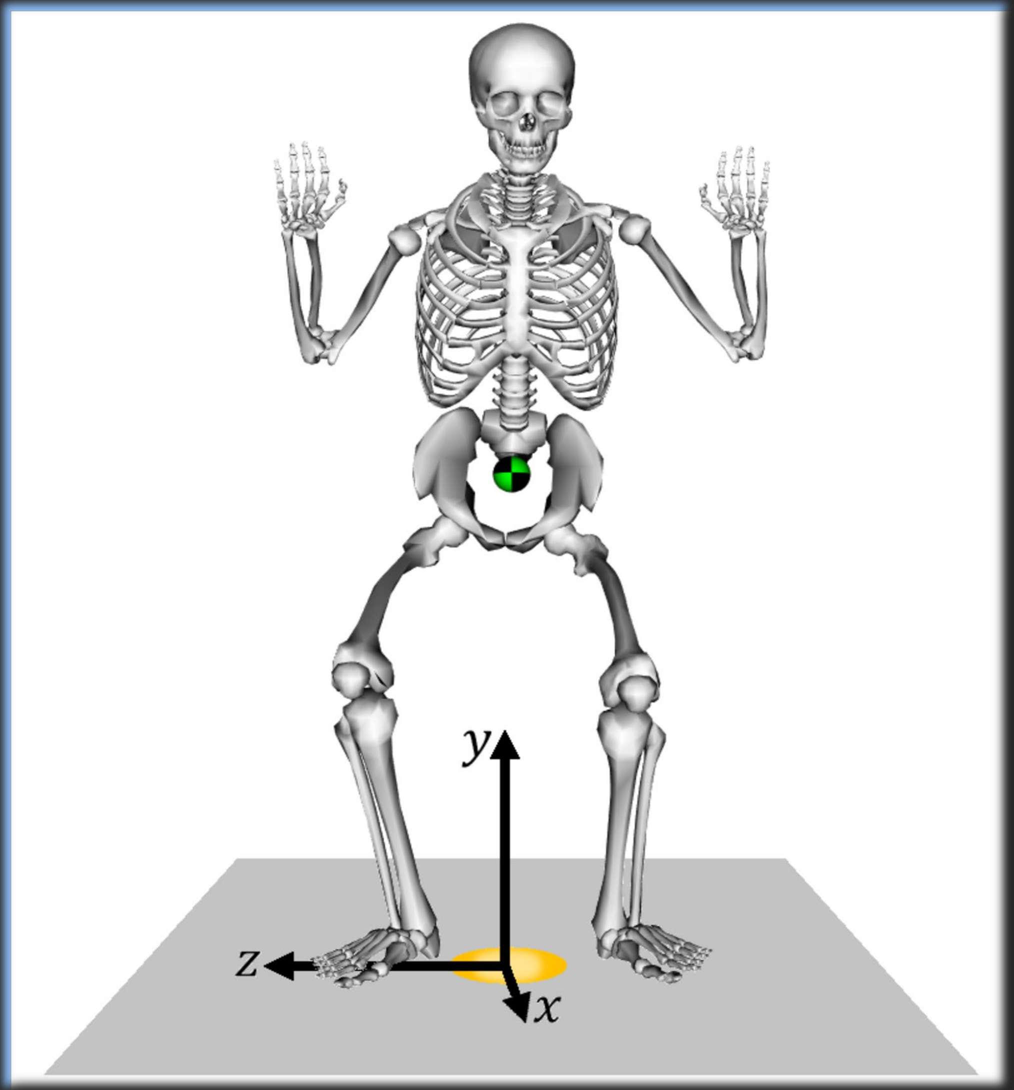


Center of Pressure Calculation

- COP was calculated from the following equations in the frame with the origin in the platform plane and the vertical y direction normal to the surface:

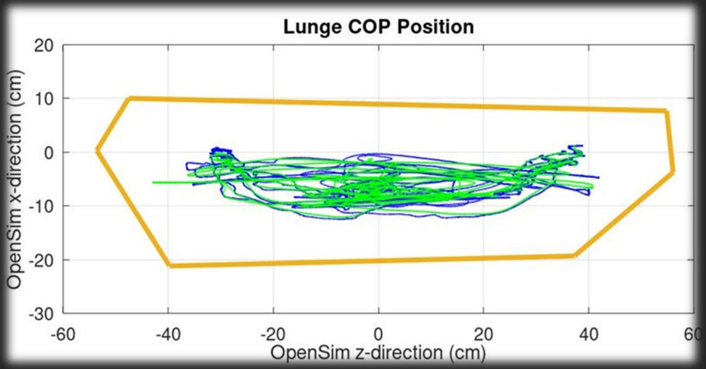
$$r_x^{(cop)} = \frac{M_z^{(plate)}}{F_y^{(plate)}} \qquad r_z^{(cop)} = -\frac{M_x^{(plate)}}{F_y^{(plate)}}$$

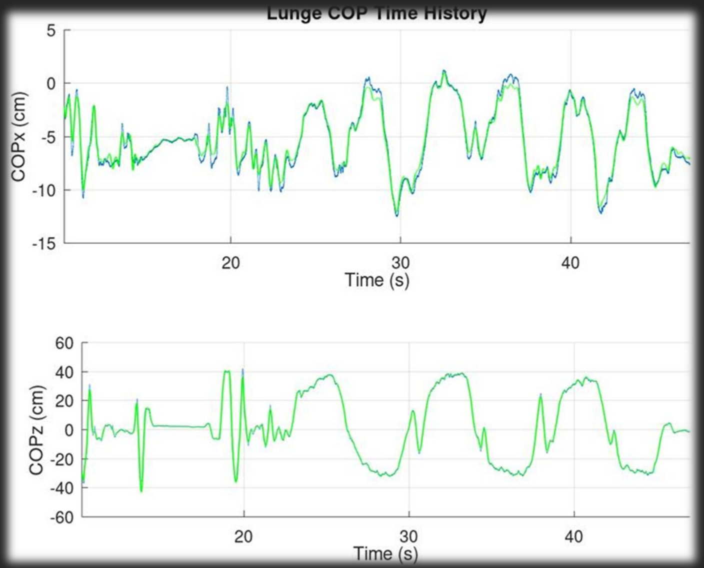
- To analyze the sensitivity of COP location to errors in quantities that determine it, COP equations were expressed in terms of:
  - Cable force and location
  - Human center of mass (CM) position, acceleration, and angular momentum with respect to the CM
- The most significant sensitivity to error is observed when the vertical force on the feet approaches zero (i.e., errors are amplified)

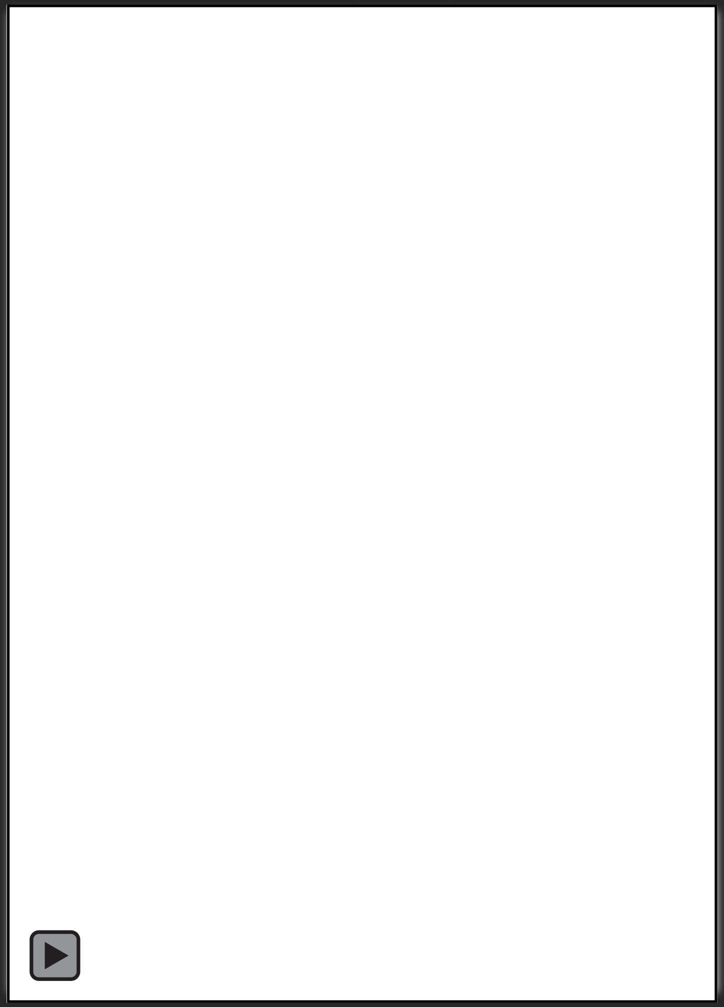


Results

- The mean error between calculated and measured COP was found to be < 6 mm across all trials (a variety of unit tests, lunar tasks, and countermeasures exercises)
- There were two cases in which the COP was observed to briefly exit the BOS in motion capture-based but not force platform results (e.g., one head range of motion and one explosive exercise)
- Techniques to mitigate IK artifacts and filtering of calculated data were used to improve the agreement of calculated and measured accelerations, resolving excursions from the BOS within this dataset







Conclusions

- Motion capture combined with biomechanical modeling allows the COP and the BOS to be determined
- In general, motion capture-based COP determination closely follows measured COP from force platform
- The COP calculation is particularly sensitive to error when the vertical force on the feet approaches zero
- Techniques to mitigate IK artifacts and filtering of calculated data can be used to improve the agreement of calculated and measured results

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